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5.0 ALTERNATIVES ANALYSIS

This chapter considers whether reasonable alternatives to the Project exist that offer substantial environmental advantages to the Project, while still being able to feasibly attain Duke Avenal's basic Project objectives. As described in Chapter 2.0 - Project Description, Duke Avenal's basic Project objectives are to:

- Provide environmentally sound, efficient and reliable power generation for California's restructured energy market.
- Use a location that has existing nearby infrastructure (i.e., existing transmission lines, water supply and gas supply) with available capacity and supply to support the Project.
- Develop a site consistent with community planning and existing zoning, at a location that is supported by the local community.
- Minimize the impacts on environmental resources.

The selected Site was chosen based on its physical, environmental and land use characteristics consistent with the above objectives. It is a flat piece of property located in an active farming region and in proximity to supporting infrastructure (natural gas, electric transmission, water supply). The Site and surrounding lands are frequently and intensively disturbed by agricultural activities (e.g., ripping, plowing, fertilizing, planting, irrigating, harvesting), so there will be no disturbance to natural habitat as a result of the Project. The Site is within the City of Avenal in an area that is zoned as an industrial park and is a distance of approximately 6 miles from the City's residential and business districts. As a result, there will be minimal environmental impact from Project construction and operation. Other considerations include support for the Project by the City of Avenal and by Kings County.

5.1 INTRODUCTION

The Commission's power plant citing proceeding is a certified functional equivalent process to the environmental review required by CEQA. The alternatives analysis required by Commission regulations in CCR, Title 20, Appendix B, is similar to the CEQA requirement to analyze alternatives. Thus, CEQA provides further guidance regarding the appropriate level of alternatives analysis to include in this AFC.

The selection of alternatives for consideration in this analysis is governed by the rule of reason, which requires an environmental document to "set forth only those alternatives necessary to permit a reasoned choice" (CCR Title 14, Section 15126.6[f]). The key issue is whether the selection and discussion of alternatives fosters informed decision-making and public participation based on the various economic, environmental, social and technological factors involved. An environmental document need not consider an alternative where the effect cannot be reasonably ascertained and where implementation is remote and speculative (CCR Title 14, Section 15126.6[f][3]). For purposes of this analysis, the reasonable range of alternatives considered is: (1) the "no project" alternative; (2) power plant site alternatives; (3) cooling alternatives; (4) transmission interconnection alternatives and (5) technology alternatives (see Appendix 5-1).

Alternatives considered in this analysis are described and evaluated in the sections below. A comparative analysis of alternatives follows the separate evaluations and is summarized in Table 5.1-1.

5.2 NO PROJECT ALTERNATIVE

The "no project" alternative is defined as the Project not being developed. The Site would remain in its existing condition and would be available for continued agricultural use or another proposal for an industrial facility consistent with the City's industrial park development.

With the recent growth in California's economy, and the continued population growth in California, the Commission has determined that California will need a substantial amount of additional generation capacity over the next several years. The Project will serve to fill part of the identified need. The Project will provide competitively priced power to the California electricity market to help meet the state's growing demand for electricity and to help replace less efficient generation resources retired due to age or cost of producing power. The "no project" alternative would not meet these objectives. If the project is not constructed, virtually any alternative site will result in a greater level of impacts than the proposed Project.

It is reasonable to predict that additional power generating capacity will be built in California and, consequently, that the net affect of implementing the "no project" alternative is that future electrical generating capacity will be delayed and likely displaced to other sites. Duke Avenal is committed to constructing the Project in an expedient manner and already has turbines that can be installed for the Project. The "no project" alternative could substantially delay the development of an adequate capacity of modern, efficient, power generation in the state and continue to place the regional demand for electricity on older fossil fuel-fired steam/electric power plants and simple-cycle gas turbine

TABLE 5.1-1
COMPARATIVE ANALYSIS OF ALTERNATIVES

ALTERNATIVES	FEASIBILITY CRITERIA			ENVIRONMENTAL IMPACT CRITERIA																
	Commercial Availability	Implementability	Cost Effectiveness	Air Quality	Geology Hazards	Agriculture and Soils	Water Resources	Biological Resources	Cultural Resources	Paleontological Resources	Land Use	Socioeconomics	Traffic and Transportation	Noise	Visual Resources	Waste Management	Hazardous Materials	Public Health	Worker Safety	Transmission System Safety and Nuisance
THE PROJECT																				
• Proposed Configuration Using Combined-Cycle Technology	High	High	High	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low to Moderate	Moderate	Moderate	Low	Low	Low
NO PROJECT	High	High	Low	●	❍	❍	❍	❍	⊗	⊗	⊗	●	❍	❍	❍	❍	❍	❍	❍	❍
ALTERNATIVE SITES																				
• Site A	Low(1)	Low(1)	Low(1)	⊗	⊗	⊗	⊗	⊗(3)	⊗(3)	⊗(3)	●	⊗	⊗	⊗	●	⊗	⊗	⊗	⊗	⊗
• Site B	Moderate(2)	Moderate(2)	Moderate(2)	⊗	⊗	⊗	⊗	⊗(3)	⊗(3)	⊗(3)	●	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
COOLING ALTERNATIVES																				
• Brackish Water	Low	Low	Low	●	⊗	●	●	●	●	⊗	●	⊗	⊗	⊗	⊗	●	⊗	⊗	⊗	⊗
• Wastewater	Low	Low	Low	●	⊗	●	●	●	●	⊗	●	⊗	⊗	⊗	⊗	●	⊗	⊗	⊗	⊗
• Once-Through Cooling	High	Low	High	⊗	⊗	⊗	●	●	⊗	⊗	⊗	⊗	⊗	⊗	❍	❍	⊗	⊗	⊗	⊗
• Natural Draft Cooling Tower	High	Low	Moderate	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	❍	●	⊗	⊗	⊗	⊗	⊗
• Air-Cooled Condenser	Moderate	Moderate	Low	●	⊗	⊗	⊗	⊗	⊗	⊗	●	⊗	⊗	●	●	❍	⊗	⊗	⊗	⊗
• Hybrid Cooling	Low	Low	Low	●	⊗	⊗	⊗	⊗	⊗	⊗	●	⊗	⊗	●	●	❍	⊗	⊗	⊗	⊗
ALTERNATIVE TRANSMISSION LINE ROUTES																				
• Route A	High	High	High	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	●	⊗	⊗	⊗	⊗	❍
• Route B	Moderate(2)	Moderate(2)	Low(2)	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	●	⊗	⊗	⊗	⊗	❍
• Route C	Moderate(2)	Moderate(2)	Low(2)	⊗	⊗	●	⊗	●	⊗	⊗	●	⊗	⊗	⊗	●	⊗	⊗	⊗	⊗	●
ALTERNATIVE GENERATING TECHNOLOGIES																				
• Oil and Natural Gas																				
- Conventional Boiler-Steam/Turbine	High	Moderate	Low	●	⊗	⊗	●	⊗	⊗	⊗	⊗	⊗	⊗	⊗	●	⊗	●	⊗	⊗	⊗
- Supercritical Boiler/Steam/Turbine	High	Moderate	Low	●	⊗	⊗	●	⊗	⊗	⊗	⊗	⊗	⊗	⊗	●	⊗	●	⊗	⊗	⊗
- Simple Combustion Turbine	High	High	Low	●	⊗	⊗	❍	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
- Kalina Combined Cycle	Low	Low	Moderate	⊗	⊗	⊗	❍	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	●	⊗	⊗	⊗
- Advanced Gas Turbine Cycles	Low	Low	High	⊗	⊗	⊗	●	⊗	⊗	⊗	⊗	⊗	⊗	⊗	●	●	●	⊗	⊗	⊗
- Fuel Cells	Low	Low	Low	⊗	⊗	⊗	❍	⊗	⊗	⊗	⊗	⊗	⊗	⊗	●	⊗	⊗	⊗	⊗	⊗
• Coal																				
- Conventional Furnace/Boiler Steam Turbine/Generator	High	Low	Moderate	●	⊗	●	●	●	⊗	⊗	●	●	●	●	●	●	●	●	●	⊗
- Atmospheric and Pressurized Fluidized Bed Combustion	Moderate	Low	Moderate	●	⊗	●	●	●	⊗	⊗	●	●	●	●	●	●	●	●	●	⊗
- Integrated Gasification Combined Cycle	Low	Low	Moderate Low	●	⊗	●	⊗	●	⊗	⊗	●	●	●	●	●	●	●	●	●	⊗
- Direct and Indirect Fuel Combustion Turbines	Low	Low	Low	●	⊗	●	❍	●	⊗	⊗	●	●	●	●	●	●	●	●	●	⊗
- Magnetohydrodynamics	Low	Low	Low	●	⊗	●	❍	●	⊗	⊗	●	●	●	●	●	●	●	●	●	⊗
• Nuclear Reactions	Moderate	Low	Low	❍	●	●	●	●	⊗	⊗	●	●	●	⊗	●	●	●	●	●	⊗
• Water																				
- Hydroelectric	Low	Low	Low	❍	⊗	●	●	●	●	●	●	●	⊗	●	●	❍	❍	⊗	⊗	⊗
- Geothermal	Low	Low	Low	❍	●	●	●	●	●	⊗	●	●	⊗	⊗	⊗	❍	❍	⊗	⊗	⊗
- Ocean Energy Conversion	Low	Low	Low	❍	⊗	⊗	❍	●	⊗	⊗	●	●	⊗	⊗	●	❍	❍	⊗	⊗	⊗
• Biomass	High	Low	Low	●	⊗	⊗	●	⊗	⊗	⊗	●	⊗	●	⊗	●	●	⊗	⊗	⊗	⊗
• Municipal Solid Waste	Moderate	Low	Low	⊗	⊗	⊗	●	⊗	⊗	⊗	●	⊗	●	⊗	●	●	⊗	⊗	⊗	⊗
• Solar Radiation																				
- Solar Thermal	Moderate	Moderate	Low	❍	⊗	●	❍	●	●	●	●	⊗	⊗	❍	●	❍	❍	⊗	⊗	⊗
- Solar Photovoltaic	Moderate	Moderate	Low	❍	⊗	●	❍	●	●	●	●	⊗	⊗	❍	●	❍	❍	⊗	⊗	⊗
- Wind Generation	Moderate	Moderate	Moderate	❍	⊗	●	❍	●	●	●	●	⊗	⊗	●	●	❍	❍	⊗	⊗	⊗
ALTERNATIVE NO_x CONTROL																				
• XONON™	NA(4)	Low	Low	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	❍	❍	⊗	⊗
• $SCONO_x$™	NA(4)	Low	Low	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	❍	❍	⊗	⊗
ALTERNATIVE INLET AIR COOLING																				
• Evaporative Cooling	High	Moderate	Moderate	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
• Inlet Fogging	High	Moderate	Moderate	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗

31161/AFC Avenal/Tbls (9/26/01/rw)

LEGEND: ❍ = Less Impact; ⊗ = Same or Similar Impact; ● = Greater Impact.
(1) Land not available. See Section 5.3.1.
(2) Land availability and commercial terms not determined.
(3) Presence or absence of sensitive resources not determined for alternative sites. It is expected that impacts at the alternative sites would be similar to or greater than at the selected Site.
(4) Not available at the scale of a 7FA turbine.

peaking plants. These plants have less efficient technology than the Project with more fuel required and more air emissions per unit of power generated.

As a merchant power plant, the business risk associated with construction and operation of the Project will be borne entirely by Duke Avenal. No ratepayer or public monies will be placed at risk. The "no project" alternative would not serve to insulate ratepayers or taxpayers from risk, but instead could harm ratepayers by decreasing competition and thereby increasing electricity prices. In addition, with the "no project" alternative, projected socioeconomic benefits related to Project construction and operations employment, local expenditures, and additional sales and property taxes would not occur.

As described in Section 5.3, the Site has been selected, in part, to minimize impacts of development on the environment. The "no project" alternative would likely displace needed future power development to a different site that would have environmental impacts at least as great as the Project.

The "no project" alternative would not serve the growing needs of California's residents and businesses for economic, reliable and environmentally sound power resources.

5.3 POWER PLANT SITE ALTERNATIVES

The Site was selected for the Project in part because the Site can be developed with minimal environmental impacts. Key characteristics considered during the Site selection process that are most relevant to minimizing environmental impacts include:

- The Project is consistent with the City's industrial land use zoning and industrial park.
- The Site is located distant from existing communities, and development of the Project at the Site is supported by the City.
- The Site is located proximal to necessary infrastructure. The short infrastructure tie-ins that will be required can be constructed and operated with no disturbance to natural habitat.
- The Site is located such that views from most receptor locations are muted by distance and land configuration (e.g., Project facilities from most receptor locations will not modify the skyline).
- There are no threatened or endangered species known to inhabit the Site.

In addition to the selected Site, two other locations were considered to see if their use instead of the selected Site could substantially reduce impacts of the Project. These alternative site locations are provided in Figure 5.3-1 and are described further in the following subsections. The alternative sites analyzed were selected by screening lands in the region to identify parcels that typify at least some of the favorable characteristics of the Site, to maximize the assurance that sites that might reduce impacts of the Project, if present, would be identified.

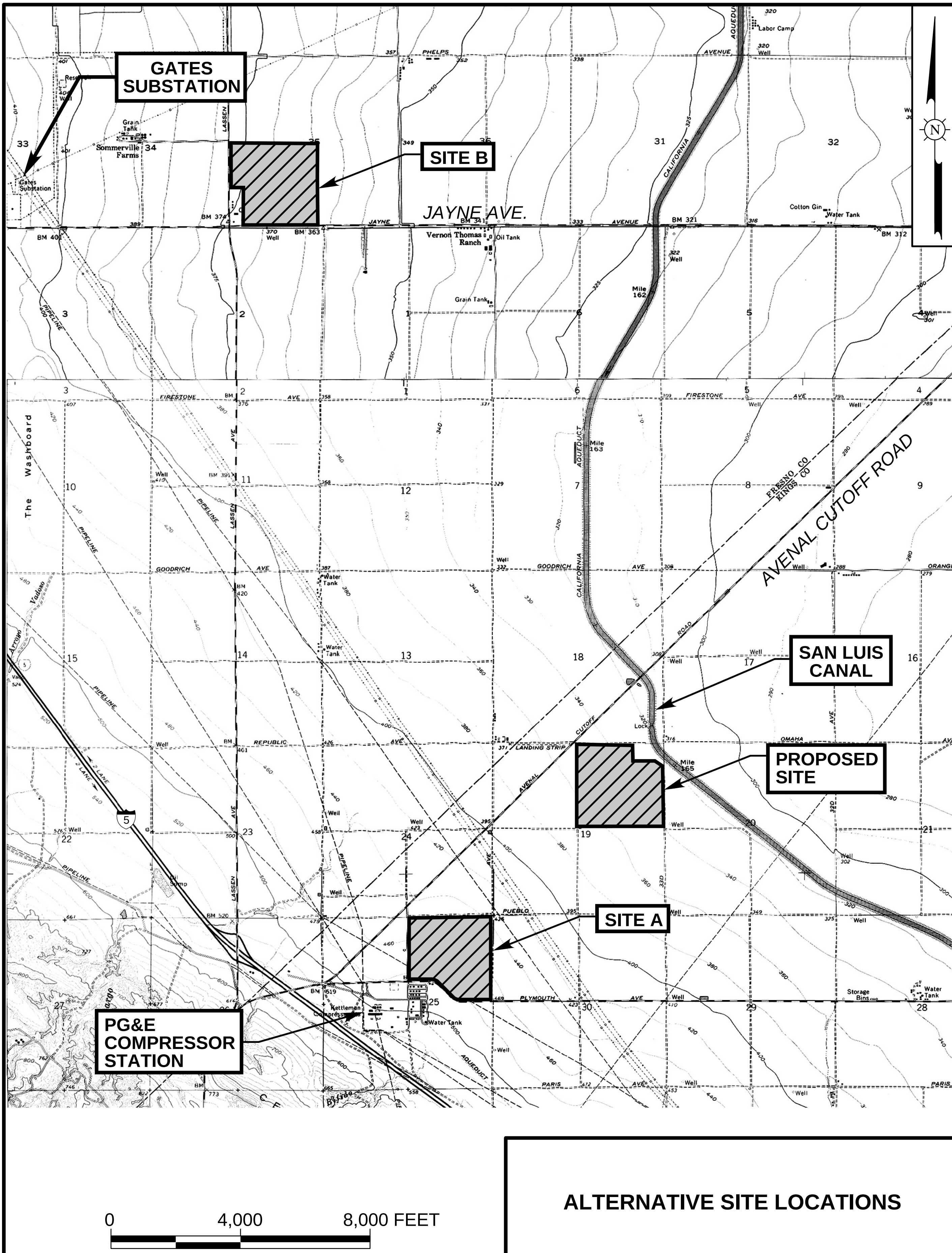
5.3.1 ALTERNATIVE SITE A

Alternative Site A is located within the City of Avenal near the Kettleman compressor station. This site consists of the majority of a quarter section bounded on the west, north and east by unimproved dirt roads (34 1/2 Avenue Alignment, Pueblo Avenue and 34th Avenue, respectively) and on the south by Plymouth Avenue. This site is also within the City's industrial park, where development of a power plant would be consistent with existing land use designations. In addition, this site is located distant from developed communities and close to necessary infrastructure. Site A has been extensively disturbed by agriculture and could be developed without impacting native habitat. There are no California Natural Diversity Data Base (CNDDB) occurrences on Site A. The closest CNDDB occurrences that are recorded for the vicinity are west of Interstate 5.

Because of the similar site conditions and similar magnitude of disturbance that would be required, it is expected that environmental impacts of the Project at Alternative Site A would be similar compared to the selected Site. Electrical transmission and natural gas interconnections would be somewhat shorter, but water is farther away. Duke Avenal was not able to obtain site control for Site A. There are no identifiable environmental benefits to Site A compared to the selected Site.

5.3.2 ALTERNATIVE SITE B

Alternative Site B is located approximately 3 miles north of the selected Site in Fresno County, near the Gates substation. Site B is almost a complete quarter section, bordered on the south by Jayne Avenue and on the west by Lassen Avenue (Route 269). Site B is zoned agricultural and is actively farmed. Site B is about 1 mile from the Gates substation and about 1-1/4 miles from PG&E's large natural gas transmission line. The San Luis Canal is approximately 2 miles east of



REFERENCE: U.S.G.S 7.5 MINUTE TOPOGRAPHIC SERIES MAPS OF HURON, CALIFORNIA, DATED 1971 AND LA CIMA, CALIFORNIA, DATED 1978.

ALTERNATIVE SITE LOCATIONS

DUKE ENERGY AVENAL, LLC

AVENAL ENERGY	**FIGURE 5.3-1**

Site B. Site B has been extensively disturbed by agriculture and could be developed without impacting native habitat. There are no CNDDB occurrences on Site B. The closest CNDDB occurrences that are recorded for the vicinity are west of Interstate 5.

Development of Site B would result in a need for more linear corridor disturbance than the selected Site, because Site B is a similar distance to electrical transmission lines and to the PG&E gas line, but considerably further from the canal. Site B is located approximately the same distance from regional transportation routes, and in a similar topographic setting as the selected Site, so visual effects would be approximately the same as with the Project. Site B is not zoned industrial like the proposed site in Avenal. There are no identifiable environmental benefits of Site B that would reduce environmental impacts compared to use of the selected Site and, consequently, no justification for the increased linear corridor disturbances, or for seeking to rezone Site B from Agricultural to Industrial.

5.4 COOLING ALTERNATIVES

5.4.1 WATER SUPPLY ALTERNATIVES

In order to evaluate alternative water sources and cooling technologies, the Project's primary water source must be fully understood. The 2,250 acre-feet per year surface water supply for the Project is a firm supply. KCWA local water reserved for Nickel Family, LLC, will be delivered to Duke Avenal by exchange. SWP entitlement water or other water will be physically delivered to the Project via the San Luis Canal to the City of Avenal's turnout. In exchange, KCWA will replace the water with an equal amount of KCWA local water. This water supply will not increase the KCWA's demand for SWP water and the source of local water provided for this exchange will not be SWP water. The exchange between local water and SWP water will not alter delivery of water to KCWA member units. The KCWA's annual SWP entitlement is in excess of one million acre-feet.

The water is available, at the Project's election, in different amounts at different times of the year. The Project can, therefore, use more water during high demand months and less water during lower demand months for a total yearly consumptive use of 2,250 acre-feet. The local water supply owned by the Nickel Family, LLC is expected to be sold to the highest bidder. The commercial terms of this water are such that it is likely to be limited to urban development (municipal use) or power plants.(1) This surface water is economic only for municipal power plant or other commercial or industrial uses.

(1) Department of Water Resources, Initial Study and Proposed Negative Declaration, Water Purchase Agreement Between Kern County Water Agency and the California Department of Water Resources for the Environmental Water Account (February 8, 2001) at page 9.

The groundwater backup supply is necessary for continuous, uninterrupted operation of the Project. The surface water supply will be delivered to the Project via the San Luis Canal. Most of the year, the canal provides high quality water, but occasionally, due to flooding or other disruptions, this water can become unusable. During these events, or in the unforeseen need to operate the Project in excess of 80 percent capacity for the entire year to support California's electric needs, the Project will be able to access groundwater. Whenever the Project uses groundwater, farm practices will be altered such that an equivalent reduction in the amount of agricultural pumping will occur. Thus, the total amount of groundwater pumped will not increase due to the Project.

Consistent with Commission rules, this application discusses potential alternative water sources for the Project and why these sources are not feasible (Title 20, CCR Appendix B(g)(14)(c)). This section includes a discussion of the primary water demand for the Project. Water supply alternatives evaluated considered State Water Resources Control Board Resolution 75-58, Water Quality Control Policy on the Use and Disposal of Inland Cooling Waters Used for Power Plant Cooling. The Project's consistency with this policy is described in Section 6.5 - Water Resources. Resolution 75-58 establishes a State Water Resources Control Board preferred water source hierarchy for sources of inland power plant cooling water. Use of wastewater flows to the ocean and ocean water are preferred sources of cooling water pursuant to Resolution 75-58 and are not feasible due to geographic isolation from the ocean.

Brackish waters, wastewater, and other inland waters also are identified as potential inland power plant cooling water sources within the heiarchy of Resolution 75-58. These alternatives were evaluated for the Project as described in the following sections. They were found to be either not feasible or not environmentally preferable to the selected sources of cooling water.

5.4.1.1 Brackish Waters

Section 6.5 - Water Resources provides a description of water resources that occur in the Project region. As further described in that section, agricultural drainage in the area results in brackish waters that occur near the floor of the San Joaquin Valley. These waters were considered to determine if they could be used for the Project.

Brackish shallow groundwater occurs in the lower portion of the valley east of the Site. The brackish water salinity is in the range of 10,000 to 20,000 microsiemens per centimeter (uS/cm) beginning approximately 6 miles east of the Site (SJVDP, 1990). Molybdenum, arsenic and other metals are dissolved in this water at elevated concentrations. Brackish shallow groundwater in some areas of the valley floor is removed by agricultural drains, such as the Tulare Lake main drain located approximately 15 miles east of the Site (Summers Engineering, 1992).

Use of the brackish water is not environmentally preferable to the proposed water supply for many reasons, including:

- Due to the shallow nature of the brackish water-bearing zone, a large array of relatively shallow wells would be needed to provide a reliable volume of water over the long-term. Water would be drawn from near-surface groundwater over a large area, potentially requiring fifty or more vertical wells or large horizontal seepage collection trenches.
- A large network of water piping would be required to collect the water, and a long pipeline would have to be constructed to convey the water to the Site.
- The extensive water collection and conveyance facilities would have substantial environmental impacts due to disturbance to land use and biological resources. The pipeline would have to cross numerous roads, drainages and the San Luis Canal to reach the Site.
- Pumping stations that would be required to transport the water would result in noise impacts and would consume power, with related impacts of nonrenewable fuel consumption and emissions to air.
- The removal of the shallow water would cause drawdown of the near-surface water, with related effects to the surface ecosystem. For example, areas of natural vegetation and wetlands that occur within the agricultural area would be adversely affected.
- Due to the poor water quality, even with treatment of the water, the cycles of concentration in the cooling system would significantly decrease. The Project would require a much larger volume of water to operate.
- The poor quality water would substantially increase PM_{10} emissions from the Project cooling tower per unit of power generated.
- The amount of salt cake that would be generated by the ZLDF if brackish waters were treated would be significantly greater than with the proposed water supply.
- The amount of truck traffic from the Site for hauling of salt cake away from the Site would, therefore, increase.
- The brackish waters contain elevated concentrations of heavy metals and pesticide residue. The resulting salt cake from ZLDF treatment of this water could have characteristics that would render it a hazardous waste.

Considering all of the increased environmental impacts that would occur from use of the brackish water, this alternative is not environmentally preferable to the proposed Project water supply.

5.4.1.2 Wastewater

Effluent from publicly owned treatment works (POTW) in the region was evaluated as a potential source of cooling water for the Project. The level of treatment that has been performed on water exiting a POTW varies, but most POTWs treat to primary and secondary levels. This water is satisfactory for some irrigation and agricultural uses, but not for drinking water. The water from most POTWs would require further treatment before being used in any power plant cooling system. Table 5.4-1 shows POTWs in the vicinity of the Site, their current average output of wastewater and the current disposition of the wastewater.

Due to the poor water quality, even with treatment of the water, the use of POTW effluent would decrease the cycles of concentration in the power plant cooling system, resulting in increased water consumption. There is no source of adequate wastewater available for the Project. The largest

TABLE 5.4-1

PUBLICLY OWNED SEWAGE TREATMENT PLANTS IN THE PROJECT VICINITY

POTW	DISTANCE FROM SITE (miles)	PLANT CAPACITY (MMgpd)	CURRENT PLANT AVERAGE OUTPUT (MMgpd)	ESTIMATED PLANT OUTPUT(1) (AFY)	CURRENT DISPOSITION OF WASTEWATER	ESTIMATED POTENTIALLY AVAILABLE QUANTITY (AFY)(2)	SUITABILITY FOR PROJECT USE
City of Avenal	10	1.75	1.25	1390	100% delivered to Avenal State Prison under Joint Powers Agreement between Avenal and State. Prison delivers to farmer for irrigation.	None	Sufficient quantity is not available.
City of Coalinga	18	1.2	0.9	980	95% sold for farming; 5% evaporated/ percolated.	50	Sufficient quantity is not available.
City of Huron	8	0.5	0.5	550	100% goes to evaporation percolation ponds.	550	Sufficient quantity is not available.
City of Lemoore	22	2.5	2.5	2,800	100% sold for farming.	None	Sufficient quantity is not available.
Lemoore NAS	17	2.12	1.75	1,970	100% goes to grinder and then to settling ponds and then to evaporation ponds.	1,970	Sufficient quantity is not available. Furthermore, volume is subject to allocation limits that may reduce supply by up to 75%.
City of Corcoran	26	1.8	1.2	1,350	80% goes to evaporation ponds, 20% sold to prison.	1,080	Sufficient quantity is not available.
City of Hanford	32	5.5	4.85	5,430	100% goes to farmers to take and use for irrigation.	None	Sufficient quantity is not available.

(1) Estimated based on current plant average output multiplied by 365.
(2) Estimated plant output minus volume committed to existing uses.

potential source of POTW effluent possibly available, Lemoore NAS, cannot guarantee a predictable water supply because:

- The effluent is virtually untreated.
- Is a long distance from the Site.
- There is not an adequate annual supply.

Even if an adequate volume of effluent were available from one of these POTWs, this source would, for many reasons, result in increased environmental impacts compared to the proposed Project water supply, as follows:

- A long pipeline would have to be constructed to convey the water to the Site. The pipeline would have to cross numerous roads, drainages and the San Luis Canal to reach the Site. The pipeline would have land use and biological effects greater than the proposed Project water supply.
- Pumping stations that would be required to transport the water would consume power, with related impacts of nonrenewable fuel consumption and emissions to air.
- The poor quality water would substantially increase PM_{10} emissions from the Project cooling tower, resulting in higher emissions per unit of power generated.
- The amount of salt cake that would be generated by the ZLDF if POTW effluent were treated would be much greater than will be required for the proposed water supply.
- The amount of truck traffic from the Site for hauling of salt cake away from the site also would increase.

Considering these factors, use of POTW effluent for the Project water supply is neither feasible nor environmentally preferable to the proposed Project water supply.

5.4.2 ALTERNATIVE COOLING TECHNOLOGIES

There are currently three cooling technology alternatives that are technically feasible for rejecting heat from the steam turbine surface condenser: wet cooling, dry cooling and hybrid wet/dry cooling. Wet cooling can utilize once-through cooling or a conventional evaporative cooling tower. Dry cooling requires an air-cooled condenser, and hybrid wet/dry cooling requires a conventional evaporative cooling tower plus an air-cooled condenser. These cooling technology alternatives are described in the following sections.

5.4.2.1 Once-Through Cooling

This technology passes a steady stream of water through the steam condenser/heat exchanger to condense the steam exiting the steam turbine. The water makes a single pass through the condenser/heat exchanger, entering at the ambient temperature of the water supply and exiting at an increased temperature due to the heat removed in condensing the steam. Conceivably, water could be taken from the aqueduct, passed through the condenser/heat exchanger and then returned to the canal. There would be no loss of water from evaporation at the plant since the system is closed and heat is removed solely through a rise in the cooling water temperature, but the evaporation rate from the aqueduct downstream may be increased due to the elevated water temperature.

Once-through cooling technology requires a large water throughput for effective cooling and to keep the temperature increase of the water within acceptable limits. A temperature rise of 15 to 20 degrees Fahrenheit (°F) would be typical. This level of increase in temperature is expected to be unacceptable to downstream water users. For these reasons, this technology was eliminated from additional consideration.

5.4.2.2 Natural-Draft Cooling Tower

A natural-draft cooling tower system is similar in principal to the Project's mechanical draft system described in Chapter 2 - Project Description. The primary difference is that the mechanical fans to move the cooling air are replaced by what is essentially a very large chimney. Air is drawn in at the base of the tower due to the less dense, warmer air that is expanding and rising to exit the top of the tower. This natural air circulation contacts the returned cooling water inside the tower and cools the water, mainly by evaporation. As a result, the cooling water recirculation, blowdown, and makeup rates and quality would be similar to the selected mechanical draft system.

A natural-draft cooling tower to serve the Project would be approximately 175 feet in diameter at the base and about 300 to 400 feet in height. This alternative was eliminated based on the adverse visual impact of such a massive structure.

5.4.2.3 Air-Cooled Condenser

In the air-cooled condenser system, exhaust steam from the steam turbine is cooled and condensed in a large external heat exchanger, using atmospheric air as the cooling medium. Large, electric motor-driven fans move large quantities of air across finned tubes (similar in principle to an automobile radiator), through which the exhaust steam is flowing. Heat transfer from the hot steam to the air cools the steam, which condenses and is returned to the steam cycle.

Most of the Project water demand is for make-up due to evaporative losses from the cooling tower, which would be avoided if air-cooled condenser technology were used. However, a trade-off would occur by not using the proposed Project water supply and allowing it to be used for urban development which increases environmental impacts.

Air-cooled condensers for power plants are very large structures and consume significant amounts of power for operation of the fans. The large fans required for air-cooled condensers also can markedly increase plant noise levels. Noise impacts are substantial and require extensive abatement. The large fans also substantially reduce steam turbine output due to higher condensing temperatures compared to cooling with mechanical draft cooling towers. As a result, for the same fuel input, the plant will generate less power due to the higher back pressure and the higher auxiliary loads of the fan motors, making the plant less efficient.

It is estimated that an air-cooled condenser for the Project would occupy over 1 acre more than the selected cooling system, extend to a height of 90 to 110 feet, and reduce the plant's electrical output. This would increase visual and land use impacts of the Project. The air-cooled condenser alternative would significantly diminish the net power output and operating efficiency of the Project, increasing fuel-burning emissions per unit of electricity generated.

If the proposed Project water source were to have significant environmental impacts associated with its use, then an air-cooled condenser might require further consideration. However, the total lack of environmental impacts of the water used for the Project does not justify the tradeoff. Due to these factors, the air-cooled condenser option was eliminated from additional consideration.

5.4.2.4 Hybrid Wet/Dry System

A parallel condensing wet/dry system utilizes a parallel condensing cooling system where the steam turbine exhaust steam is condensed simultaneously in both a standard steam surface condenser (SSC) and in an air cooled direct condenser (ACC). This parallel cooling system is sometimes called a "hybrid" system.

The amount of steam condensed in each device depends on the overall heat rejection load, availability of makeup water and ambient conditions. During operation, the condensing pressures in both the SSC and ACC constantly equilibrate due to self-adjustment of steam flows entering each device. For example, if the water temperature in the surface condenser were incrementally raised, steam flow to the surface condenser would decrease. Steam flow to the direct condenser then would increase, and turbine backpressure would increase slightly. As ambient conditions, load conditions and heat rejection capability of each device vary over time, the steam flow to each automatically adjusts without any active components being required on the steam side. Steam flowing to the SSC is taken off the main steam duct in a manner that best suits the specific steam turbine exhaust configuration and steam duct routing to the ACC. A conventional circulating water system interconnects the SSC with a conventional mechanical draft cooling tower system. Steam condensed in the SSC is returned to the main condensate tank via a condensate forwarding pump. The air ejection system is appropriately connected to both the SSC and the ACC.

The primary benefit of this type of system is that, if a small amount of makeup water is available, a "wet" side or cooling tower can be used to enhance cooling efficiency relative to full dry cooling. The ACC fans of the hybrid system dry side are operated are operated at full speed during the warmer periods of the year. When in operation, the hybrid system wet side cooling tower fan speeds are adjusted to maintain a prescribed evaporation rate. Compared to the proposed cooling system, for the same fuel input, the plant would generate less power due to higher backpressure and auxiliary loads, making the plant less efficient.

It is estimated that, with a hybrid wet/dry system, the Project would occupy over 1 acre more than with the selected cooling system, the dry side would extend to a height of 90 to 110 feet, and the plant's electrical output would be reduced. In addition, more fuel must be burned in order to generate the same power as from the Project, resulting in an increase in air emissions compared to the Project.

If the proposed Project water source were to have significant environmental impacts associated with its use, then a hybrid wet/dry system might require further consideration. However, the lack of environmental impacts of the water used for the Project does not justify the tradeoff. Hence, this alternative was eliminated.

5.4.2.5 Conclusion

The technical merits of each alternative cooling technology were considered, and wet cooling (with a mechanical draft cooling tower) was selected for the Project based on the following:

- Substantially increased noise impacts for dry and hybrid wet/dry cooling.

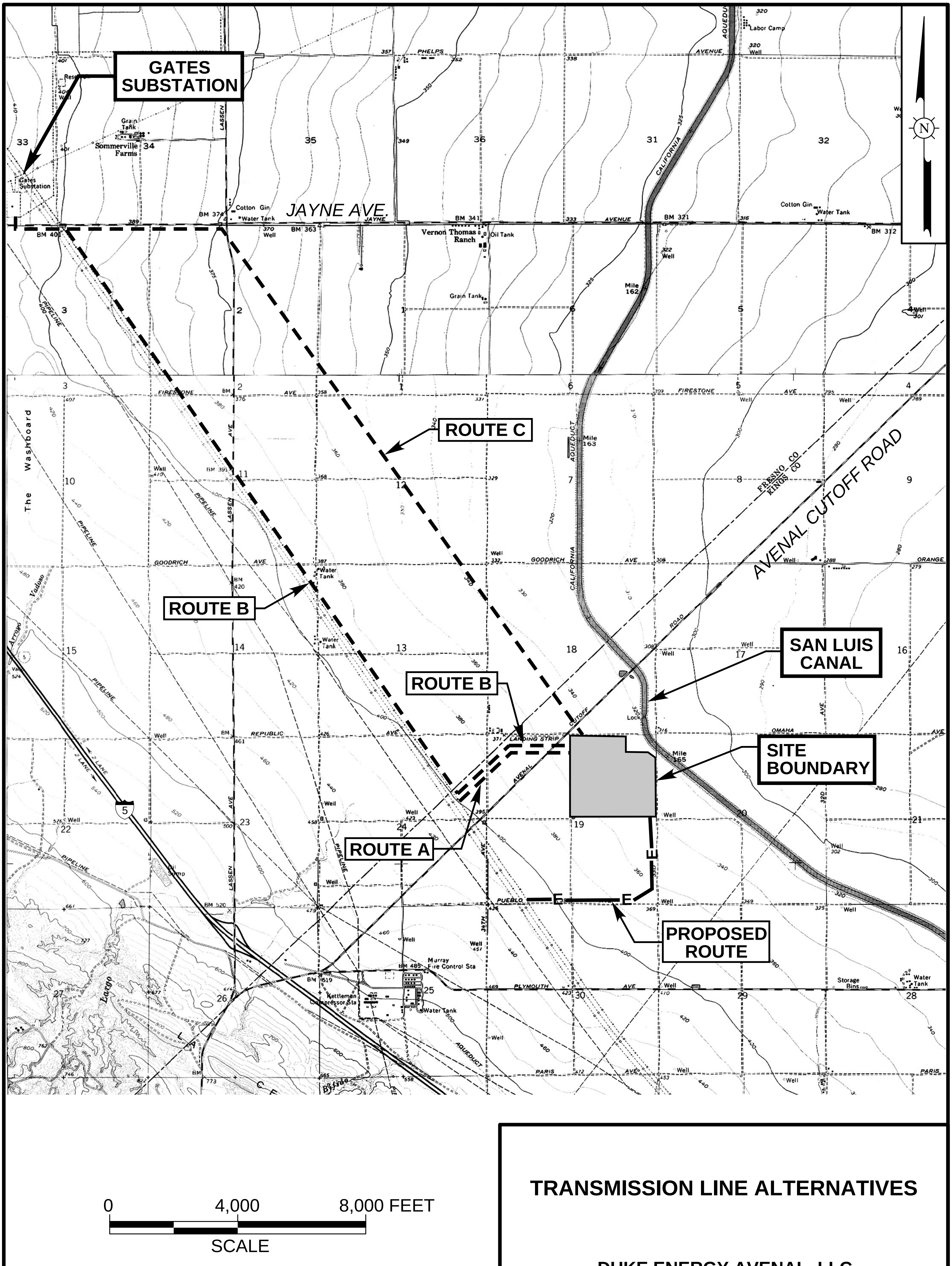
- Steam turbine output is lower with dry and hybrid wet/dry cooling, which results in lower plant efficiency.
- The reduced plant efficiency of dry and hybrid wet/dry cooling would result in increased emissions to air per unit of power generated, compared to the proposed cooling technology.
- Electrical load for dry and hybrid wet/dry cooling system is higher, therefore reducing the plant's efficiency and net electrical output.
- Dry cooling or hybrid wet/dry cooling would substantially add to the mass and visual presence of the facility.
- Balanced against the nonimpact of the proposed Project water source, there is no net environmental benefit.
- Since the surface water supply will be used by industrial or municipal uses, the environmental impacts from the use of this surface water elsewhere will be equivalent to or substantially greater than the environmental impacts of water use for this Project.
- Significantly higher economic costs over the life of the Project for dry and hybrid wet/dry cooling.

5.5 ELECTRICAL TRANSMISSION LINE INTERCONNECTION ROUTE ALTERNATIVES

The electrical transmission line interconnection route is shown in Figure 5.5-1, and the interconnection is described in detail in Section 2.4. The route was selected for the Project in part because it minimizes environmental impacts. Key characteristics considered in conjunction with the electrical interconnection route selection process that are most relevant to minimizing environmental impacts include:

- The selected route is located away from developed roads so that views from most receptor locations are muted by distance.
- The selected route is located away from Avenal Cutoff Road and, consequently, will not interfere with the road frontage as the City's industrial park is developed.
- The selected route traverses land that is exclusively used for agriculture, and there are no residences or other developments in proximity to the selected route.
- The selected route traverses intensively disturbed lands, so no disturbance to natural habitat or threatened or endangered species will occur.

In addition to the selected route, several other electrical interconnection routes were considered to see if their use could substantially reduce impacts of the Project. These alternative routes are provided in Figure 5.5-1 and described further in the following sections.



REFERENCE: U.S.G.S 7.5 MINUTE TOPOGRAPHIC SERIES MAPS OF HURON, CALIFORNIA, DATED 1971 AND LA CIMA, CALIFORNIA, DATED 1978.

TRANSMISSION LINE ALTERNATIVES

DUKE ENERGY AVENAL, LLC

AVENAL ENERGY | FIGURE 5.5-1

5.5.1 ROUTE A

Alternative Route A exits the northwest corner of the Site and traverses due west across Avenal Cutoff Road and then parallels the Kings/Fresno County line to the existing transmission lines. This route would consist of a "loop-in" interconnection that, with the exception of the alignment, would be similar to the proposed interconnection described in detail in Section 2.4.

Similar to the selected route, Route A would be relatively short and would be constructed entirely on lands that have been extensively disturbed by agriculture. There would be no substantive difference in environmental impacts for Route A compared to the selected route except that Route A would cross Avenal Cutoff Road. This proposed route is inconsistent with the City of Avenal's desires to not place large electric transmission structures and wires near Avenal Cutoff Road and hence was rejected.

5.5.2 ROUTE B

Alternative Route B is different from the selected route and alternative Route A in that this route is a direct tie-in to the Gates substation, located approximately 5 miles northwest of the Site. Route B exits the northwest corner of the Site and traverses due west across Avenal Cutoff Road, then parallels the Kings/Fresno County line to the existing transmission lines, and then parallels the existing transmission lines to the Gates substation. For the purposes of this alternatives analysis, it is considered that use of Route B could involve upgrading (i.e., removal and replacement) of existing conductor wire between the Site vicinity and the Gates substation, addition of a new conductor wire on existing towers, or construction of a new tower line to the Gates substation.

Use of Route B would require generally the same amount of new line construction between the Site and the existing transmission corridor compared to the selected route. However, an additional approximately 4 miles of interconnection work would be required to connect to the Gates substation. Route B would be entirely on lands that have been extensively disturbed by agriculture and are generally similar to the lands traversed by the selected route. Route B crosses Avenal Cutoff Road which is not preferred by the City of Avenal. If new towers or reconductoring was required for this route this would be a more costly alternative to the selected route.

5.5.3 ROUTE C

Alternative Route C is similar to Route B in that this route is also a direct tie-in to the Gates substation located approximately 5 miles northwest of the Site. Route C exits the northwest corner of the Site and traverses northwest across Avenal Cutoff Road and agricultural fields to Jayne Avenue.

Use of Route C would require construction of approximately 5 miles of a new tower line to the Gates substation. Route C would be entirely on lands that have been extensively disturbed by agriculture and are generally similar to the lands traversed by the selected route. Route C would result in increased disruption to local farmers because it represents approximately five times the length of new tower line construction. Consequently, Route C was rejected.

5.6 TECHNOLOGY ALTERNATIVES

A wide variety of technology alternatives were studied to determine the most appropriate configuration for the Project. The Project will be a merchant plant and, as such, will be providing electricity in a deregulated market. The ability of the Project to operate efficiently in a deregulated market is paramount to the success of the venture, so the generating technology proposed has been carefully selected. The following sections include a discussion of power generating technologies, fuel technology alternatives, combustion turbine alternatives, NO_x control alternatives and inlet air cooling alternatives. Cooling technology alternatives are addressed in Section 5.4.2.

5.6.1 SELECTION METHODOLOGY

Technologies considered were primarily those that could provide baseload or load-following power as opposed to those that would provide peaking or intermittent power. The reason for using this screening criterion was that the operating efficiency of the facility is interrelated with the substantial investment in its design.

The selection methodology included a stepped approach, with each step containing a number of criteria. The selected technology would have to pass Steps 1 and 2 and provide the lowest or near lowest cost in Step 3. The steps are:

- **Step 1 - Commercial Availability** - The technology had to be proven commercially practical with readily available, reliable equipment.
- **Step 2 - Implementable** - The technology had to be implementable; that is, it must meet environmental, public safety, public acceptability, fuel availability, financial and system integration requirements.

- **Step 3 - Cost-Effective** - The technology had to be incrementally cost competitive, not only with existing generating units, but also with units that will probably enter the newly deregulated market during the early commercial operation period of the Project. Incremental cost considerations include capital as well as operation and maintenance (O&M) costs, which would translate into a busbar cost represented in cents per kilowatt-hour.

This methodology was applied to a number of base load and load-following technologies as described in the following sections.

5.6.2 ALTERNATIVE NATURAL GAS-FIRED TECHNOLOGIES

Selection of the power generation technology focused on those technologies that can utilize natural gas. These technologies include conventional boiler-steam turbine units, combustion turbines in various configurations, and fuel cells.

5.6.2.1 Combined-Cycle (Selected) Generating Technology

This technology integrates combustion turbines and steam turbines in a combined cycle to achieve higher efficiencies compared to simple-cycle technologies. The combustion turbine drives a generator and, instead of being released to the atmosphere as they would under a single-cycle configuration, the exhaust gases from the combustion turbine are instead used to produce steam that drives an additional generator. The resulting efficiency of the system is 50 to 54 percent, considerably above most other alternatives. This efficiency results in relatively low air emissions per kilowatt-hour generated. In addition, natural gas fuel emits little sulfur dioxide and little particulate matter. For these reasons, the system is considered the benchmark against which all other base load technologies are compared. This technology is commercially available and can be implemented. Because of its high efficiency and relatively low cost of generation, this technology is cost-effective. This technology is the one selected for the Project, as well as most other new base load and load following units being developed in the United States.

5.6.2.2 Conventional Boiler-Steam/Turbine

In conventional boiler-steam/turbine technology, fuel is burned in a furnace/boiler to create steam, which is passed through a steam turbine that drives a generator. The steam is condensed and returned to the boiler. This is an aging technology that is able to achieve a maximum thermal efficiency on the order of 35 to 40 percent. Applying the review methodology, the technology is definitely commercially available and could probably be implemented. However, due to its relatively low efficiency, it tends to emit a greater quantity of air pollutants per kilowatt-hour generated than more efficient technologies. Furthermore, its cost of generation is higher than the selected combined-cycle technology. This technology therefore does not satisfy Step 3 and was eliminated from further consideration.

5.6.2.3 Supercritical Boiler-Steam/Turbine

This technology is basically the same as the conventional boiler-steam/turbine except it utilizes considerably higher pressures. Plants using this type of technology are more expensive to construct per unit of power generated compared to conventional boiler-steam/turbine plants. Higher construction costs are generally offset by increased efficiency, so cost of power produced is about the same as a conventional boiler-steam/turbine plant. Applying the review methodology, the technology is definitely commercially available and could probably be implemented. However, because it is not as efficient as the combined-cycle technology, it would emit a greater quantity of air pollutants per kilowatt hour compared to the Project. This technology was eliminated due to its being less efficient than the selected combined-cycle technology. Based on the lower efficiency, this technology does not satisfy Step 3 and was eliminated from consideration.

5.6.2.4 Simple Combustion Turbine

This technology uses a gas or combustion turbine to drive a generator. Air is compressed in the compressor section of the combustion turbine, then passed into the combustion section where fuel is added and ignited. The resulting hot combustion gases pass through a turbine, which drives a generator. The combustion turbines have a relatively low capital cost and have efficiencies approaching 40 percent in the larger units. Because they are fast-starting and have a relatively low capital cost, they are used primarily for meeting high peak demand (about 1,000 hours/year), where their relatively low efficiency compared to combined-cycle technology is not a concern. Applying the review methodology, this technology is definitely commercially available and could be implemented. However, due to its lower efficiency compared to the selected combined-cycle technology, it would tend to emit a greater quantity of air pollutants per kilowatt hour generated. Also, the incremental cost of generation, if it were base-loaded, would be relatively high. The technology, therefore, does not satisfy Step 3 and was eliminated from consideration.

5.6.2.5 Kalina Combined Cycle

This technology is similar to the conventional combined cycle except water in the heat recovery boiler is replaced with a mixture of water and ammonia. Overall efficiency is expected to be increased 10 to 15 percent. However, this technology is still in the testing phase. Applying the review methodology, the technology fails to pass Step 1, since it is not commercially available. It was therefore eliminated from consideration.

5.6.2.6 Advanced Gas Turbine Cycles

There are a number of efforts to enhance the performance and/or efficiency of gas turbines by injecting steam, by intercooling and by staged firing. These include the steam-injected gas turbine (SIGT), the intercooled steam recuperated gas turbine (ISRGT), the chemically recuperated gas turbine (CRGT) and the humid air turbine (HAT) cycle. With the exception of the SIGT, none of the technologies is commercially available, so they all fail to pass Step 1 of the review methodology. The SIGT is marginally commercially available and might pass Steps 1 and 2 of the review methodology, but its efficiency is lower than conventional combined-cycle technology, so it fails on Step 3. Consequently, all of these technologies were eliminated from consideration.

5.6.3 FUEL ALTERNATIVES

Technologies based on fuels other than natural gas, such as fuel cells, coal and oil, nuclear, solar and water, are described in the following sections.

5.6.3.1 Fuel Cells

This technology uses an electrochemical process to combine hydrogen and oxygen in order to liberate electrons, thereby providing a flow of current. The types of fuel cells include phosphoric acid, molten carbonate, solid oxide, alkaline and proton exchange membrane. With the exception of the phosphoric acid fuel cell and possibly the molten carbonate fuel cell, none of these technologies is commercially available on the scale of a commercial power plant. Therefore, they fail Step 1. The phosphoric acid fuel cell has operated in smaller size units, and the molten carbonate fuel cell has completed testing. At this time, however, neither of these technologies is cost competitive with conventional combined-cycle technology. Therefore, fuel cells fail Step 3 of the review methodology.

5.6.3.2 Coal

The technologies that use coal for fuel include conventional furnace/boiler steam turbine/generator, fluidized bed steam turbine/generator, integrated gasification combined-cycle, direct-fired combustion turbine, indirect-fired combustion turbine, and magnetohydrodynamics.

Conventional Furnace/Boiler Steam Turbine/Generator

Coal is burned in the furnace/boiler, creating steam that is passed through a steam turbine connected to a generator. The steam is condensed in a condenser, passed through a cooling tower and returned to the boiler. Designs include stoker, pulverized coal and cyclone. The efficiency of this technology is equivalent to a conventional gas/oil fired steam turbine/generator unit (35 to 40 percent) and, because of the usually lower price of coal compared to natural gas, the technology can be cost competitive under most conditions. However, the tons of air emissions per kilowatt-hour generated are greater than for a conventional combined-cycle because of its lower efficiency, resulting in more fuel consumed per kilowatt-hour. Applying the review methodology, the technology is definitely commercially available (Step 1). The technology should be implementable in California except for possible public perception that large coal-fired units cause visible air emissions (untrue with modern units). In addition, coal would have to be imported from outside California (resulting in increased truck and/or train traffic), and the time to construct a facility would probably be about twice that for a conventional combined-cycle unit. The technology may therefore not pass Step 2. In addition, the generation cost of the technology could be greater than for a combined cycle (Step 3). Due to the potential problems under Step 2 and the potentially higher cost in Step 3, the technology was eliminated from consideration.

Atmospheric and Pressurized Fluidized Bed Combustion

Both of these technologies burn coal in a hot bed of inert material containing limestone that is kept suspended or fluidized by a stream of hot air from below. Water coils within the furnace create steam that drives a steam turbine/generator. The combustion chambers of the pressurized units operate at 150 to 250 psig to increase efficiency. Efficiencies of atmospheric fluidized bed combustion (AFBC) units are on the order of 35 to 40 percent; pressurized (pressurized fluidized bed combustion [PFBC]) units are between 40 and 45 percent. The technology is commercially available for the AFBC technology, at least up to the 160-MW size. The PFBC technology is not commercially available. Applying the review methodology, the AFBC may pass Step 1, but the PFBC is eliminated from consideration. Implementation of the AFBC technology in California is possible, particularly for cogeneration applications (several new units have recently been constructed). Coal would have to be imported from outside California, increasing train and/or truck traffic. The technology should pass Step 2, although possibly not for the 600-MW size that the applicant has planned. The generation cost of the technology, however, could be greater than for a combined cycle (Step 3). Due to the lack of a commercially proven unit in the 600-MW range, and the potentially higher cost, the AFBC technology was eliminated from consideration.

Integrated Gasification Combined-Cycle

Integrated gasification combined-cycle (IGCC) gasifies coal to produce a medium Btu gas that is used as fuel in a combustion turbine, which exhausts to an HRSG that supplies steam to a steam turbine/generator. The coal gasifier is located at the same site as the combustion turbine, HRSG and steam turbine/generator. It is sized to supply the combustion turbine and is integrated with it and the rest of the equipment to provide an integrated generating system. While a 100-MW unit has been fully tested in California, the technology is probably not fully commercially available. Applying the review methodology, the IGCC will not pass Step 1. Implementation of the IGCC technology in California is possible, except that coal would have to be imported from outside California (resulting in increased truck and/or train traffic). The generation cost of the technology could be competitive with a conventional gas-fired combined cycle (Step 3), but this is a relatively unknown factor. Due largely to the probable lack of full commercial availability, particularly in the 600-MW range, IGCC technology was eliminated from consideration.

Direct- and Indirect-Fired Combustion Turbines

Direct-fired units burn finely powdered coal directly in the combustion chamber of the combustion turbine. Indirect-fired units burn the coal in a fluidized bed or other combustor. Both use a heat exchanger to transfer the heat from the combustion gases to air, which is then expanded through the turbine. Neither of these units is commercially available. Therefore, they both fail to pass Step 1 of the selection methodology and were eliminated from consideration.

Magnetohydrodynamics

High temperature (3,000ºF) combustion gas is ionized and passed through a magnetic field to directly produce electricity. This technology is not commercially available. Therefore, it fails to pass Step 1 of the review methodology and was eliminated from consideration.

5.6.3.3 Nuclear Reactions

Nuclear technology includes nuclear fission and nuclear fusion. Nuclear fission breaks atomic nuclei apart, giving off large quantities of energy. For nuclear fission, pressurized water reactors (PWRs) and boiling water reactors (BWRs) are commercially available. California law prohibits new nuclear plants until the scientific and engineering feasibility of disposal of high-level radioactive waste has been demonstrated. To date, the Nuclear Regulatory Commission has been unable to make the findings of disposal feasibility required by law for this alternative to be viable in California. Nuclear fission would also require very large quantities of fresh water for cooling, a resource that is not readily available. The technology therefore is not implementable and fails to pass Step 2 of the review methodology. It was therefore eliminated from consideration.

Nuclear fusion forces atomic nuclei together at extremely high temperatures and pressures, giving off large quantities of energy. Nuclear fusion is not available commercially, and it is not clear if or when it will become available. The technology, therefore, fails to pass Step 1 of the review methodology and was eliminated from consideration.

5.6.3.4 Water

These technologies use water as "fuel." They include hydroelectric, geothermal and ocean energy conversion.

Hydroelectric

This technology uses falling water to turn turbines that are connected to generators. A flowing river or, more likely, a dammed river, is required to obtain the falling water. This technology is commercially available. However, most of the sites for hydroelectric facilities have already been developed in California, and any remaining potential sites face formidable environmental licensing problems. There are no large bodies of water near the Avenal Site that can be used for hydroelectric power. Therefore, it would fail to pass Step 2 of the review methodology. It was therefore eliminated from consideration.

Geothermal

These technologies use steam or high-temperature-water (HTW) obtained from naturally occurring geothermal reservoirs to drive steam turbine/generators. There are vapor dominated resources (dry, superheated steam) and liquid-dominated resources that use a number of techniques to extract energy from the HTW. Geothermal is a commercially available technology. However, geothermal resources are limited, and most, if not all, currently economic resources have been discovered and developed in California. Geothermal development is not viable at the Project location. It was, therefore, eliminated from consideration.

Ocean Energy Conversion

A number of technologies use ocean energy to generate electricity. These include: tidal energy conversion, which uses the changes in tide level to drive a water turbine/generator; wave energy conversion, which uses wave motion to drive a turbine/generator; and ocean thermal energy conversion, which employs the difference in water temperature at different depths to drive an ammonia cycle turbine/generator. While all of these technologies have been made to work, they are not fully commercially available. Even if they were commercially available, they are considerably more costly than conventional combined-cycle technology and so would fail Step 3 of the review methodology. They were therefore eliminated from consideration.

5.6.3.5 Biomass

Major biomass fuels include forestry and mill wastes, agricultural field crop and food processing wastes, and construction and urban wood wastes. Several techniques are used to convert these fuels to electricity, including direct combustion, gasification and anaerobic fermentation. While these technologies are available commercially on a limited basis, their cost tends to be high relative to a conventional combined-cycle unit burning natural gas. This technology, therefore, does not pass Step 3 of the review methodology and was eliminated from consideration.

5.6.3.6 Municipal Solid Waste

This technology consists of extracting energy from garbage by burning or other means, such as pyrolysis or thermal gasification, and is commonly referred to as waste-to-energy (WTE). The most efficient known methods incorporate mass burn and refuse-derived fuel (RDF) facilities. Both mass burn and RDF are commercially available methods of municipal solid waste (MSW) technology. Other methods are co-firing with coal, using fluidized-bed furnace/boilers, and pyrolysis or thermal gasification. There is only one 10-MW mass burn unit operating in California and no RDF facilities or facilities using the other methods. The economic feasibility of MSW technology depends heavily on the level of the "tipping fee" in the vicinity of the MSW facility. The tipping fee is the price charged by landfills for depositing waste or garbage in the landfill, and it is usually expressed in dollars per ton. In effect, a waste collection company would pay the WTE facility for taking and burning its garbage, resulting in a negative fuel cost to the WTE. A recent study for development of a WTE facility in the San Francisco area estimated that the tipping fee would have to be about $80 per ton for a facility to be economical. The current tipping fee in the area ranges from $30 to $40 per ton. Tipping fees in Kings County are lower than in San Francisco. This technology therefore fails to satisfy Step 3 of the review methodology, which requires the technology to be cost competitive. This technology was therefore eliminated from consideration.

5.6.3.7 Solar Radiation

Solar radiation (sunlight) can be collected directly to generate electricity with solar thermal and solar photovoltaic technologies, or indirectly through wind generation technology in which the sunlight causes thermal imbalance in the air mass, creating wind. Wind generation and two types of solar generation, thermal conversion and photovoltaics, were considered as alternative technologies to the combined cycle. These are described in the following subsections.

Solar Thermal

Most of these technologies collect solar radiation, then heat water to create steam to power a steam turbine/generator. The primary systems that have been used in the United States capture and concentrate the solar radiation with a receiver. The three main receiver types are mirrors located around a central receiver (power tower), parabolic dishes and parabolic troughs. Another technology collects the solar radiation in a salt pond and then uses the heat collected to generate steam and drive a steam turbine/generator. While one of these technologies might be considered to be marginally commercial (parabolic trough), the others are still in the experimental stage. All require considerable land for the collection receivers and are best located in areas of high solar incidence. In addition, power is only generated while the sun shines, so the units do not supply power when clouds obscure the sun or from early evening to late morning. Gas-fired backup generation for the evening hours is necessary to support continuous power output and to provide steam to support solar operations. The Avenal area does not have sufficient year round sunshine to support solar power. The land use impact of the large area required for collection receivers would also be significant. These factors, for the most part, fail Step 2, and may not be implementable due to land unavailability and/or the ability to finance. Hence, solar thermal was eliminated from consideration.

Solar Photovoltaic

This technology uses photovoltaic "cells" to convert solar radiation directly to direct current electricity, which is then converted to alternating current. Panels of these cells can be located wherever sunlight is available. This technology is environmentally benign and is commercially available, since panels of cells can theoretically be connected to achieve any desired capacity. While this technology may have a bright future, at the current time the cost is higher than the selected combined-cycle technology. This technology fails Step 3, cost-effectiveness, and was therefore eliminated from consideration.

Wind Generation

This technology uses a wind-driven rotor (propeller) to turn a generator and generate electricity. Only limited sites in California have an adequate wind resource to allow for the installation of wind generators, and most of these sites have already been developed or are remote from electric load centers and have limited or no transmission access. Even in prime locations the wind does not blow continuously, so capacity from this technology is not always available. In California, the average wind generation capacity factor has been 25 to 30 percent. In addition, depending on the site and/or season, the technology cannot be depended upon to be available at system peak load since the peak may occur when the wind is not blowing. The technology is commercially available and implementable at certain sites. The technology is relatively benign environmentally, although at some sites land consumption and effects on visual resources and avian species are a concern. The cost of generation is above the cost of the selected combined-cycle technology. Due to the inavailability of good sites, limited dependability, and relatively high cost, this technology was eliminated from consideration.

5.6.3.8 Conclusion

Using the selection methodology identified in Section 5.6.1, power generating technology fuel alternatives were eliminated from consideration because they do not meet the Project objective of achieving its environmental and operational advantages. Additional factors rendering alternative fuel technologies unsuitable for the Project are as follows:

- No geothermal or hydroelectric resources exist in area.
- Biomass fuels, such as wood waste, are not locally available in sufficient quantities to make them a practical alternative fuel.
- Solar and wind technologies are not feasible at Avenal due to lack of consistent wind and sunlight.
- Coal and oil technologies emit more air pollutants than technologies utilizing natural gas.

The availability of natural gas, as well as the environmental and operational advantages of natural gas technologies, make natural gas the logical choice for the Project.

5.6.4 ALTERNATIVE COMBUSTION TURBINE TECHNOLOGIES

The latest generation of commercially demonstrated combustion turbine technology, commonly referred to as "F" technology, was selected for the Project. The selection of this class of combustion turbines was based on economies of scale, thermal efficiency, operational flexibility and proven status of commercial operation.

Currently available, large combustion turbine models can be grouped into three classes: conventional, advanced and next generation. Conventional combustion turbines operate at firing temperatures in the range of 2,000°F to 2,100°F and are available in sizes up to about 110 MW. Advanced combustion turbines operate at firing temperatures above 2300°F and are available in sizes up to about 180 MW. Next generation combustion turbines have higher firing temperatures than the advanced turbines and have additional features that provide greater output and higher efficiencies. Next generation turbines represent models that have been announced by the manufacturers as commercially available, with advertised outputs in the range of 230 to 240 MW.

Examples of commercially available combustion turbines in each class are as follows:

MANUFACTURER	CONVENTIONAL	ADVANCED	NEXT GENERATION
Alstrom Power	GT 11N2	GT 24	None
GE	7EA	7FA	7H
Siemens/Westinghouse	501D5A	501F	501G

Advanced combustion turbines offer significant advantages for the Project. Their higher firing temperatures offer higher efficiencies than conventional combustion turbines. They offer proven technology with numerous installations and extensive run time in commercial operation. Emission levels are also proven, and guaranteed emission levels have been reduced based on operational experience and design optimization by the manufacturers. In comparison, environmental performance and thermal efficiencies of next generation turbines have not been demonstrated in commercial operation.

The specific advanced combustion turbine model selected for consideration for the Avenal Energy Project is the GE 7FA. This turbine was selected on the basis of its commercially proven status, demonstrated emission levels, high thermal efficiencies and adequate operational flexibility.

5.6.5 ALTERNATIVE NO_X CONTROL TECHNOLOGIES

To minimize NO_x emissions from the Project, the CTGs will be equipped with dry low NO_x combustors, and the HRSGs will be equipped with post-combustion selective catalytic reduction (SCR), using aqueous ammonia as the reducing agent. Alternative NO_x control technologies are analyzed in Appendix 6.2-5 and summarized in this section.

The following combustion turbine NO_x control alternatives were considered:

- Steam injection (capable of 25 to 42 ppm NO_x)
- Water injection (capable of 25 to 42 ppm NO_x)
- Dry low NO_x combustors (capable of 9 to 25 ppm NO_x)

Dry low NO_x combustors were selected because they provide for lower NO_x emissions and lower HRSG makeup water requirements.

Three post-combustion NO_x control alternatives were considered:

- SCR
- XONON™
- $SCONO_x$™

The SCR is a proven technology and is used frequently in combined-cycle applications. Ammonia is injected into the exhaust gas upstream of a catalyst. The ammonia reacts with NO_x in the presence of the catalyst to form nitrogen and water and significantly lower emissions.

The XONON™, manufactured by Catalytica Combustion System, is a very new technology. XONON™ achieves NO_x as well as CO and VOC emission control through the combustion process using a catalyst to limit the combustor temperature to below the temperature where NO_x is formed. The XONON™ can produce the same amount of heat energy as a conventional combustor, but with lower temperature, thus reducing the formation of NO_x. The material of the catalyst is platinum and/or palladium. The XONON™ module is attached directly within the gas turbine combustor. The XONON™ combustor installed in the 1.5 MW Kawasaki gas turbine, which began operation on June 2000, has not yet sufficient operating data to determine that this level of control can be achieved over the long term. It still has not been tested on large-scale gas turbines. GE Power Systems, which have a collaborative agreement to commercialize the XONON™ system for GE gas turbines, indicated they are not planning to actively develop XONON™ technology for their products for at least 2 years. XONON™ was therefore eliminated from further review for the Project.

The $SCONO_x$™ is a new technology and has been installed on a 25-MW combined-cycle plant since December 1996. $SCONO_x$™ consists of an oxidation catalyst, which oxidizes CO to CO_2 and NO to NO_2. The NO_2 is adsorbed onto the catalyst, and the catalyst is periodically regenerated. Although a potentially promising technology, $SCONO_x$™ has not been commercially demonstrated on a large power plant. There are several technological and commercial issues remaining to be resolved prior to application of this new technology to the class of large combustion turbines selected for the Project.

The following reducing agent alternatives were considered for use with the SCR system:

- Anhydrous ammonia
- Aqueous ammonia
- Urea

Anhydrous ammonia is suitable for use, but its handling and storage are of more concern than is the use of aqueous ammonia. The aqueous ammonia (19 percent ammonia, 81 percent water solution) has been used in many combined-cycle facilities and has been selected for the Project. Urea has not been commercially demonstrated for use with SCR on gas turbines attempting to meet the extremely low NO_x levels proposed for the Project. Therefore, this technology was eliminated from consideration.

5.6.6 ALTERNATIVE INLET AIR COOLING TECHNOLOGIES

Combustion turbine output and efficiency both increase as inlet air temperature decreases. Ambient air temperatures for the Project are sufficiently high for a large portion of the year to warrant some form of inlet air cooling. Three available forms of combustion turbine inlet air cooling are evaporative cooling, inlet fogging and air chilling.

Both evaporative cooling and inlet fogging are capable of cooling to temperatures near the ambient wet-bulb temperature. Air chilling, on the other hand, is capable of cooling CTG inlet air to temperatures significantly below ambient wet-bulb temperatures (chilled air temperature is typically 45°F) over a wide range of ambient conditions resulting in substantial net output gains. Air chilling uses mechanical or absorption refrigeration to produce a cold fluid for cooling of the inlet air and can be designed to operate continuously.

Based on temperature profiles at the Site, mechanical inlet air chilling was selected to eliminate output reduction at high ambient temperature conditions and result in substantial net output gains.

5.7 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section presents a comparative analysis of the alternatives presented. Since the purpose of this analysis is to evaluate if there are feasible alternatives that could avoid or lessen adverse environmental impacts of the Project, the following criteria are used:

- Feasibility - This criteria includes consideration of commercial availability, implementability and cost.
- Environmental Impacts - The anticipated environmental effects of each technology are reviewed to determine if impacts would be less than, the same as or similar to, or greater than the Project.

The comparative analysis is presented in Table 5.1-1. The top row of the table shows the feasibility criteria and environmental criteria for operation of the Project. Below, the comparative analysis shows the feasibility and environmental impact criteria for operating each of the alternatives analyzed. The feasibility criteria reflect independent evaluations of commercial availability, implementability and cost-effectiveness of each alternative. Criteria for these alternatives are not absolute, but are as they would be compared to the Project. As demonstrated in the table, no feasible alternative has less overall environmental impact than the Project.

5.8 REFERENCES

City of Avenal General Plan. 1992.

City of Avenal. Rick Cunningham, Utility Superintendent. Personal Communication, 2001.

City of Coalinga. Rene Ramirez, Director of Utilities. Personal Communication, 2001.

City of Corcoran. Chris Butler, Chief Plant Operator. Personal Communication, 2001.

City of Hanford. Robert Sisneroz, Waste Water Manager. Personal Communication, 2001.

City of Huron. Oscar Ramirez, City Engineer. Personal Communication, 2001.

City of Lemoore. David Walashin, Director of Public Works. Personal Communication, 2001.

Fresno County General Plan. 1989.

Lemoore NAS. Commander Kirk Wilson, Public Works Officer. Personal Communication, 2001.

San Joaquin Valley Drainage Program (SJVDP). A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley. Final Report of the San Joaquin Valley Drainage Program. September 1990.

Sisneroz, R. Telephone conversation with Robert Sisneroz, Waste Water Manager for the City of Hanford. August 6, 2001.

Tulare Lake Drainage District (TLDD). Map prepared by Summers Engineering, Inc. Revised May 1992.